Scientific Method of Appraising Farm Lands

FOREWORD.

The writer of the following text was once sent out by a bank to make an appraisement of a farm offered as security for a proposed loan. I adopted the advice of an experienced appraiser, who told me not to interview the owner of the farm first, but to go to the owner of the adjoining farm and pretend that I heard he wanted to sell his farm, and ask for his selling price. In doing so, I was told it was not for sale, that I must have misunderstood my directions, and I asked who owned the adjoining farm and was it for sale, and at what price? I then called on the local banker, merchant, and real estate agent, asking them if they knew Mr. ———'s farm, what was it worth, etc. Afterwards I inspected Mr. ———'s farm, scraped the soil with my shoe to see if it was moist a few inches down, noted its general character, the appearance of the trees, crops, etc.

On returning to the bank, I said I thought the land was worth $150 an acre. The banker asked me on what my opinion was based. I told him whom I had interviewed, that their opinions varied from $160 to $200 an acre. "Why did you cut their opinions down to $150 an acre?" I answered, "On general principles." Then the banker said, "You base your opinion of its value on the opinions of the banker, merchant and other persons, and the first thing you did was to discredit their opinions by cutting them down without any information or reasons for doing so. You don't know whether the banker is interested in Mr. ——— obtaining this loan, so he could pay a loan past due at the bank. Maybe Mr. ——— owes the merchant, the real estate agent is a booster, and his loyalty to the community forbids him knocking any prospective sale or loan; at best your opinion was based on other persons' opinions and you don't know what their opinions were based on." My answer was, "I have followed the custom of all other appraisers, what else could I do?" His reply was, "I guess your appraisement is as good as I can get from anybody; we will make the loan based on your figures."

Instead of being flattered with his compliment, I contrasted my work with that of an appraiser of a mine, who took a sample of the ore and had it assayed, found how much it would go to the ton, in fact, a chemical analysis of the value of the mine. A buyer of raw materials invariably has a chemical analysis made; the jobber always takes a sample of the goods and has a chemical analysis made to see if it is up to representations; eggs are candled, milk is tested for butter fat. An abstract of a title, with the attorney's opinion, is simply an analysis of the title; but a farm value, in lieu of a scientific analysis, must be bought on hearsay evidence, or on opinions perhaps of those more or less interested in the examination, maybe less familiar with its true value than the inquirer.

Four years ago, I was challenged to produce a better system of farm appraisement, and to explain what a unit value should be.

The following is submitted as a result of some study, statistical information compiled by the U. S. Agricultural Department at Washington, D. C., also reports of the Agricultural Department of the University of California, which, in conjunction with the United States Agricultural Department at Washington, has been expending $20,000 a year on soil surveys in California, and in addition to its soil survey has gathered a large amount of information from county agricultural commissioners, also from their own field staff, who have personally canvassed the farmers for information.

Prof. R. L. Adams, of the University of California, in charge of the class on farm management, has compiled a wonderfully complete textbook on this subject and states in his preface: "Following the collection of the original data, the requirements for growth and costs of production have been checked and re-checked to the extent of over 300 times for requirements and nearly 300 times for costs."

I wish to record here my grateful acknowledgments of the encouragement and data I have received from Thomas Forsyth Hunt, Dean of the Agricultural Department, and other professors and employees of the Agricultural Department of the University of California, who were enthusiastic in their belief that a scientific appraisement could be devised. Such an appraisement will, I think, be of great value in furnishing prospective sellers or mortgagees the true values and possibilities of farm investments, and, in a measure, check some of the misrepresentations that are sometimes made by unscrupulous agents and owners of farm lands.

Recognizing that a single individual's opinion has but little weight, I am asking the co-operation of those who favor this attempt, to solve some of the difficulties in devising a correct method of appraising farm lands.

I wish to get ten or more opinions of the best judges of values, by analyzing some sale that has been made during the last year or two, in each county of the State, on this form of an appraisement sheet; especially of the assessor, local bankers, the purchaser, seller, real estate agent and owners of adjoining property; in fact, appraisements made on this form of appraisement by competent judges of values. After collecting a thousand or more of these appraisements, I intend to review and standardize these appraisements. I am promised not only the assistance of the Agricultural Departments of the University, but also that of members of the Associated Savings Banks of San Francisco, who would welcome a system of appraisement that would lessen the risks of loans on country lands.

As will be seen by attached instructions, I have attempted to point out the factors that go to make up each element of value, leaving it to the different appraisers to register their opinion in dollars or percentages to be added to, or deducted from, the unit 100 per cent. value.

By writing to your representative in Congress he will send you a United States soil survey of your county free, or by a letter addressed to A. G. Rice, Chief Clerk of Bureau

of Soils, Department of Agriculture, Washington, D. C., you can get list of soil surveys made and prices.

I have copied tables prepared by the Agricultural Department of the University of California, also one page from Prof. Adams' textbook on "Requirements and Method of Growing the Prune," illustrating how thorough and painstaking his work has been.

In lieu of reliable local data these tables may assist the appraiser. If more detailed information on any particular crop is needed, I will copy data similar to that on the prune.

If this method of appraisement should prove accurate and be approved by a consensus of "Community Opinions," I have no doubt it will make it easier to sell farms or obtain mortgage loans, perhaps be a standard appraisement insisted on by bank officers and purchasers, and may be as an "indispensable analysis of value" as an abstract and attorney's opinion is of the analysis of the title. Criticize it and then test it for the good of all.

Factors That Go to Make Values.

1. Average annual yield per acre.
2. Average market price.
3. Average life of tree or plant in bearing.
4. Average initial cost of planting.

4a. Average cost of upkeep until maturity.

5. Average time to bring tree into bearing maturity.
6. Average annual increase growth of tree after bearing maturity.
7. Average per cent. of crop failures.
8. Average per cent. of deterioration by tree diseases.
9. Average cost of harvesting.
10. Average cost of marketing.
11. Average cost for upkeep of trees after bearing maturity.
12. Gross income value.
13. Net income value.

13a. Total net income per acre, per year.

13b. Net income capitalized on a ten per cent. basis or 100 per cent. base value.

13c. One per cent. value in dollars and cents.

14. Total cost or expense value minus.
15. Soil survey—cost of.
16. Spotted soil.
17. Potential value plus.
18. Fertilization value plus.
19. Irrigation value plus.
20. Drainage value plus.
21. Improvement value.
22. Insurance value.
23. Loan value—Federal Farm Loan Bank.
24. Loan value—State Savings Bank.
25. Climate value, plus or minus.
26. Health value, plus or minus.
27. Moral value, plus or minus.
28. Educational value, plus or minus.
29. Social value, plus or minus.

30. Store supply value, plus.
31. Road value, plus.
32. Transportation value, plus or minus.
33. Speculative value, plus or minus.
34. Community opinion value.
35. Asking price value.
36. Title value.
37. Taxation value, plus or minus.
38. Location value.
39. Recapitulation.

The cost of insurance and taxes is omitted from the above on the assumption that the intercropping and the earnings of keeping chickens and cows for family supplies and house rent would equal the cost of taxes and insurance.

12. Gross Income.

This value is found by multiplying the average annual yield per acre (1), by the average market price (2), by the average life of the bearing tree (3); this gives the gross income per acre during the life of the bearing tree. In computing the average annual yield, the growth of the tree (6) should be included.

13. Net Value.

Will be the difference between the gross income value (12) and the cost or expense value (14). Divide this amount by the total number of years of the life of the tree, this includes the period from planting to maturity (5) and the years of profitable bearing (3). This amount divided by the number of acres will give the net average annual income per acre (13a). To capitalize this on a ten per cent. basis, multiply by ten. This will be the unit or 100 per cent. base value (13b) (13) per acre. If you wish to compute it on a five per cent. basis, double this amount and call it 200 per cent. land or call the 100 per cent. unit or base value (13) any amount that will produce a satisfactory interest capitalization.

By dividing the amount of the net income per acre per year by 100 per cent., will give the amount one per cent. (13c) represents in dollars, and is useful in finding the amount any of the factors of value expressed in percentage represents in dollars.

14. Cost or Expense Value.

This value is found by adding the initial cost of planting (4) and upkeep until maturity (4) and the cost of upkeep during the bearing life of the tree or plant (11); also the total cost of harvesting (9) and the total cost of marketing (10) for the full period it is in bearing. If the per cent. for crop failures (7) and deterioration by tree disease (8) have not been computed in the average annual yield (1), the deduction should be made by adding same to the cost or expense account.

15.—Soil Survey, Plus.

Will be the cost of the survey and the information derived from the soil survey.

16. Spotted Soil.

This is reflected in the annual crop value (1) and treatment in soil survey (15).

17. Potential Valuation.

Is the increased net income, that can be created by making a soil survey to find the adaptability of the soil for other crops by fertilization, irrigation, drainage or scientific treatment of the land. It is obtained by the same method used in finding the net income value, to wit: from the increased gross income caused by the changed conditions, deduct the additional cost; capitalize this amount on a ten per cent. basis and add the per cent. to the unit or 100 per cent. base value (13).

18. Fertilization Value.

From the net additional income in crop, due to the use of fertilization, deduct the cost of fertilization and capitalize the balance on a ten per cent. basis. In figuring the cost of fertilizing the frequency of repeating same should be estimated and prorated per acre.

19. Irrigation Value.

If a pumping plant; the cost of the plant, ditching, canals, and checking, divided by the number of acres will give the additional value per acre, and the plus per cent. value will be the proportion in percentage that the cost bears to the unit or base value.

If water is bought from a corporation or district, the cost of the water right should be added and reduced to percentage proportion of the 100 per cent. value (13). In computing the value of a water right the source of supply, quality and certainty of full supply of water should be taken into consideration.

If the water right was included in the price of the land it may be separated and added to the unit or 100 per cent. value.

20. Drainage Value.

Can be figured in the same manner as the fertilization value (18).

21. Improvement Value.

To find the acre value of the improvement, divide the cost or present value of the fences, barns, houses, etc., by the number of acres and add to the unit 100 per cent. (13) value a percentage based on the proportion this value bears to the unit or base value (13).

22. Insurance Value.

Consult the local insurance agent and he will give you the amount the insurance company will carry. This value is not reduced to a percentage value or added to the unit or base value, but is used only to show a safety factor in case of fire or loans to be obtained.

23. Federal Farm Loan Value.

This amount is fixed by law at 50 per cent. of the land value and 20 per cent. of the insurance value. It is not to be added to the unit or base value.

24. State Savings Bank Loan Value.

By State law the bank is not allowed to loan in excess of 60 per cent. of the market value. It must be borne in mind that the banker will be the final judge of the market

value and, like the Farm Loan Bank, he would welcome an appraisement showing the factors that go to make the value as contemplated by this analysis of value.

25. Climatic Value.

Taking the maximum, minimum and mean temperature and rainfall of each month for a number of years will show the liability to frosts, floods, or droughts, and an estimate may be made to cover these risks. Compute the loss in percentages and deduct from the unit value. (Bulletin L, Climatology of California, published by the U. S. Govt. in 1903, has monthly tables for most of the cities and counties in California, or local records can be used if reliable.)

26. Health Value.

Is largely a community opinion; as some persons are more immune from sickness than others. The following conditions might be considered as contributory factors to this loss or gain: If the death rate is above or below the normal, lack of good medical advice, or hospital service, prevalence of malaria or other local sickness.

27. Moral Value.

The percentage for this value will necessarily be an opinion value. The number and influence of churches, prohibition or anti-prohibition, absence of crime, might be considered factors in forming an opinion.

28. Educational Value.

Some of the factors upon which to base an opinion would be the value of schoolhouse and grounds divided by the number of acres in the school district; this would give to each acre the value of school buildings and grounds. As the State grants fifteen dollars for each child attending school, the income from this source should be capitalized on an income basis and counted as a plus amount. It is often said, children on the farm are an asset, not only to their parents but often as cheap help for adjoining farmers. Children in the country can acquire a knowledge of foods, fruits and farming that cannot be as thoroughly acquired elsewhere; besides a healthy physical condition is one of the beneficial results of farm life. There is also a sentimental value to be considered.

29. Social Value.

A congenial neighborhood has a salable value. Social parties and amusements take the place of the more expensive diversions of city life. Undesirable or inharmonious residents always depreciate property in any neighborhood, farm or city.

30. Store Supply.

Nearness to a city or store where supplies can be had at reasonable prices is not only a convenience but a true value, inasmuch as it saves time and delay in purchasing close to home. A good blacksmith shop or garage, where repairs can be made, is also important to an agricultural community.

31. Road Value.

County roads that are finished and paid for by taxa-

tion on the land are strictly a land investment and should be added to the acre value. State highways, although paid for by the State, add value to the acreage the same as those built by the county, and the better the roads the greater the asset; and, as good roads add to the pleasure of driving and lessen the cost of hauling, they can be said to contain a sentimental as well as a physical value.

32. Transportation Value.

This can be computed on the character of the service by rail or boat, as well as the cheapness of freight or passenger rates and markets to which they lead.

33. Speculative Value.

If the increase in values for the last five years has been ten per cent. and conditions appear favorable for a continuation of the conditions that led to this increase, it would be safe to estimate that the speculative or future value would continue in the same ratio; namely, two per cent. per annum.

34. Community Opinion Value.

Is hard to analyze but it is a self-evident fact. If the majority of the community think a rolling country, a house on a hill with a fine view, and many other elements are more desirable, the seller will ask more for land having these advantages and the property will be more in demand. Neat fences, flowers and shade trees add to the community opinion value.

35. Asking Price.

Is usually all the seller can get, and sometimes the representations made are inaccurate. There is no better way of measuring this than by the percentage plan of the factors that go to make up the total value. The man who knows true values and makes no mistakes would soon become the richest man in the world.

36. Title Value.

Consists of the standing of the abstract company and the lawyer who examines same, or issues the title insurance policy. The ability of the owner as a farmer, his health and habits; and, if a corporation is the owner or seller, the legality of its incorporation papers and the payment of the corporation State taxes should be looked up.

37. Taxation Value.

This value affects your pocketbook and must be judged by comparison with some other community where the expenses are less, or better and more economical government can be had. Low taxes and poor government may not be so desirable as a better government with higher taxes. The last assessment values and total tax rate should be given.

38. Location Value.

Distance from shipping point, town, city, school house, or supply store may be considered by a purchaser as having a value, plus or minus.

39. Recapitulation.

The abstract and lawyer's opinion are only analyses of the title. If a competent and reliable appraiser would furnish you with an analysis of the value as set forth in this

form of appraisement, would it be valuable to the buyer or mortgagee?

If when you approach the banker to obtain a loan, you had a scientific appraisal value made by a responsible company or individual attached to your abstract, would it aid you in obtaining your loan quickly? If scientifically made it becomes as permanent as your abstract and as available in borrowing or selling as a certificate of insurance of title. Men who buy or sell mines have an assay made of the ore as well as an examination of the title.

It is common now for merchants and manufacturers to have chemical analyses made of raw or finished products before paying for same. Would it not be equally advantageous to have an analysis made of the soil and elements of value in a farm before buying or loaning money on it? It certainly would be far more scientific and doing what the long experienced and best farmers of Europe now invariably do, assisted by government soil surveys, advice, agricultural statistics, etc.

REQUIREMENTS AND METHODS OF GROWING THE PRUNE.

Climatic Requirements—

In General: Summer heat, somewhat tempered by cool winds. Trees hardy.

Soil Requirements—

By proper selection of stock can be grown in wide range of soils. Light sands to adobe. Depth of 6' or more required.

Water Requirements—

Ample supply of moisture throughout the year. Natural rainfall often aided by irrigation.

Setting Out and Caring for Orchards to Maturity—

Distance Apart of Trees: 28' x 28'.
Average Number per Acre: 55.
Time of Planting Out: December-March.
Age to Self-Sustaining Crop: 7 years.
Age to Maturity: 10 years.
Most Popular Varieties: Prune d'Agen (French) Sugar, Imperial Robe de Sargent.
Length of Profitable Life: Estimated 40 years.
Calendar of Operations to Maturity:
Irrigation: When required, given once in furrows. June.
Pruning: Pruned annually in winter to form head.
Fertilizing: Cover crops for soils lacking in body. Usually intercropped.
Spraying: Only when needed for scale, moss and the like.
Cultivating: Plowed and cross plowed in February and March, harrowed twice, cultivated at 6 weeks' intervals, April to November.
Companion Cropping:
Intercropped to berries, small fruits, beans, beets, corn, and sometimes alfalfa. Usually discontinued after trees are 6 years old.

Caring for Bearing Orchards—

Calendar of Operations:
Irrigation: When required, given once in June by furrows or checks.
Pruning: November-February. To head in and shape tree, dead wood cut out and the brush thinned.
Fertilizing: Cover crops grown when soils lack body.
Cultivating: February-March, plowed and cross plowed. Worked down. Cultivated once or twice in April, May and June. Then in June dragged and rolled to smooth surface for prunes to fall upon.

Fumigating: None.
Thinning Fruit: Not done.
Spraying: February, lime sulphur or oil emulsion.

Harvest—

Time: August 15–October 1.
Method: Picked from ground in 3 pickings at intervals of 10 days.
Preparing for Market: Dried in sun after running through lye. (Dry 2¼ to 1.) Delivered in bulk or in barley sacks.

% of Different Grades—

Prunes sold according to size—i. e., number required to make a pound.

Yields—

Good: 3 tons.
Usual: 2 tons (dried product).

Commercial Sections—

Butte County.
Lake "
Napa "
Santa Clara "
Solano "
Sonoma "
Sutter "
Yuba "

COST OF PRODUCING THE PRUNE.

Value of Land—		
Raw land—		
High (with water)	$ 500.00	per acre
Low " "	150.00	" "
Usual " "	300.00	" "
Developed Orchards—		
High producing	1000.00	" "
Good "	800.00	" "
Usual "	600.00	" "
Cost of Establishing Orchards—		
Irrigation system or water right included in price of land—		
Clearing, grading and leveling land for planting—($6–75)	$20.00	per acre
Trees	13.00	" "
Setting out	6.00	" "
Replanting	1.50	" "
Annual Cost from Setting Out to Self-Sustaining Age—		
Cultivation ($6–12)	$ 8.00	" "
Irrigation (when given)	3.00	" "
Pruning ($2–4)	3.00	" "
Spraying	3.00	" "
(Cultivation usually borne by intercrop.)		
Annual Upkeep after Maturity—		
Cultivation ($6–12)	$10.00	" "
Spraying ($6–12)	8.00	" "
Pruning and burning brush ($6–10)	8.00	" "
Irrigation (when given)	5.00	" "
Whitewashing	2.00	" "
Propping or wiring ($1–2.50)	2.00	" "
Cost of Harvest—		
Picking up ($6–7)	$ 6.00	per dry ton
Hauling	1.00	" " "
Dipping, curing and storing	6.00	" " "
Hauling (2 miles)	1.00	" " "
Market Value of Yield (on "prune Base")—		
High	.06	per lb.
Low	.02	" "
Average	.04	" "
Taxes and Insurance—		
To Maturity	$ 2.50	per acre
After Maturity:		
Average land	6.00	" "
Good land	8.00	" "

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FORM FOR A SCIENTIFIC APPRAISEMENT OF A 10-ACRE PRUNE ORCHARD.

Owner's Name.
Location and Description.

Gross Income Value [12]

Average annual yield [1] 2 tons an acre × 10 acres × 40 years [3] = 800 tons.
Average market price [2] 4 cts. a lb. = $80 a ton × 800 tons = ... $64,000.00

Less Cost or Expense Value [14]

Initial cost of planting [4] $40.50 × 10 acres=	405.00
Annual cost of upkeep until maturity [4a] $17.00 × 7 years × 10 acres	1,190.00
Annual cost of upkeep after maturity [11] $35.00 × 40 years × 10 acres	14,000.00
Cost of harvesting [9] and marketing [10] $14.00 a ton × 800 tons	11,200.00
Total Expense [14]	$26,795.00
Net income [13]	37,205.00

Net income an acre a year $37,205 ÷ 10 acres ÷ 47 years [13a] = $79.19 an acre.
$79.19 [13b] × 10% = $791.90 an acre or 100% value or $7.92 for 1% value [13c].
Nothing allowed for crop failures, etc., taxation or insurance.

Improvement Value [21]

Value of houses, barns and fences, $2,000. This amount divided by 10 (no. of acres) equals $200. $200 divided by $7.92, value of 1% [13c], equals 25¼%. This gives an additional value of 25¼%, which is to be added to the base or 100%, making 125¼% value. Other factors of value will be added to or deducted from the base or 100% value in the same manner as the case may be.

Cost of soil survey [15]
Cost of fertilization [18]
Cost of irrigation [19]
Cost of drainage [20]
Climate value [25]
Health value [26]
Moral value [27]
Educational value [28]
Social value [29]
Store supply value [30]
Road value [31]
Transportation value [32]
Speculative value [33]
Community opinion value [34]
Asking value [35]
Title value [36]
Taxation value [37]
Insurance value [22]
Loan value, Federal Farm Loan Bank [23]
Loan value, State Savings Bank [24]
Location value [38]

Figures inside of brackets refer to the numerical order of Factors that go to make values.

CHARACTERISTICS OF CALIFORNIA SOILS.*

In the humid regions of the world, and especially in the humid region of the United States, practically nine-tenths of the soils are either of residual or of glacial origin. The glacial soils have been transported and deposited by ice, and while the glacial deposits may be very deep, the true soil is not deep. The subsoil is usually heavier than the surface, often clayey, and the practical feeding depth of roots is usually less than four feet. The residual soils are much more extensive than the glacial soils. They are formed

* By Charles F. Shaw, Professor of Soil Technology.

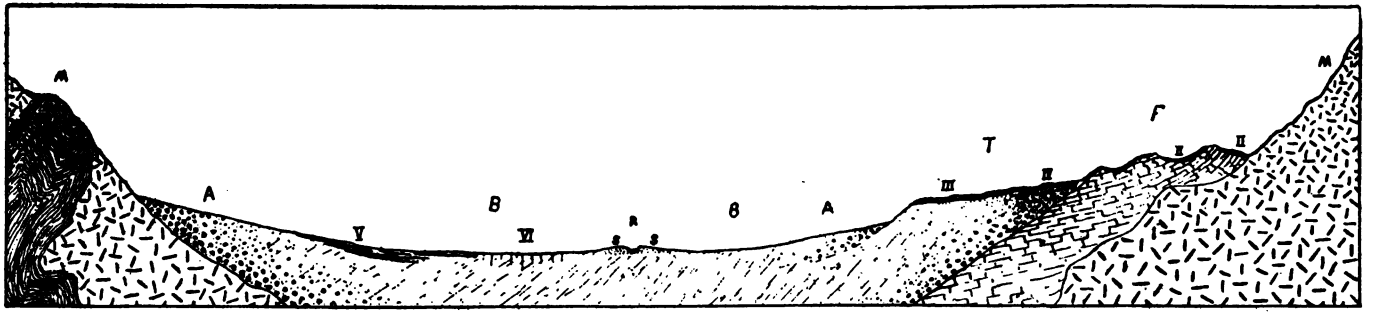

Fig. 1.—Typical section of a California valley. *M-M*, Mountains on either side of valley, washed bare of soil. *F*, Foothills with residual soil (Fig. 2). *T*, Old, eroded alluvial fan, now a terrace, usually with hardpan (Figs. 3 and 4). *A-A*, Alluvial fans, usually gravelly and sandy near the mountains and silty and clayey on the flatter slopes; usually free from hardpan except on some of the older and flatter slopes (Fig. 5). *B-B*, Nearly level flood plain and basins, usually with heavy (clayey) soils, often with adobe structure (Fig. 6). *R*, River with built up banks, *S-S*, of sandy and silty soils.

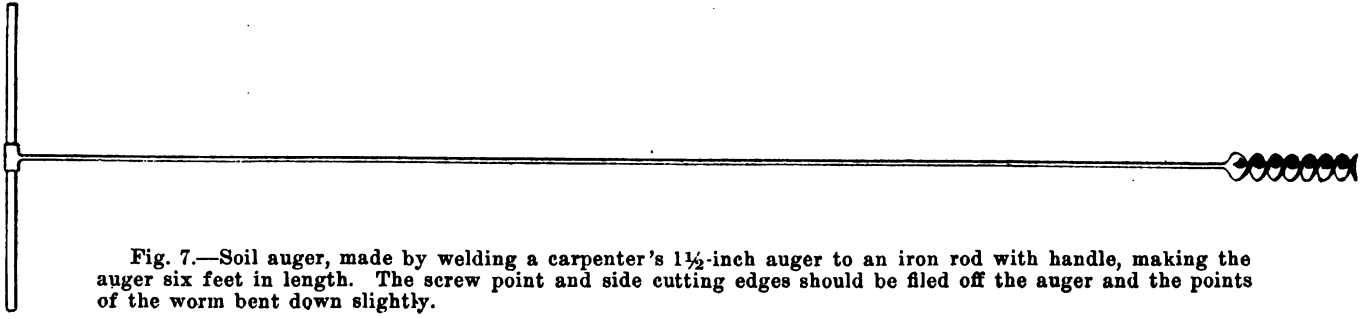

Fig. 7.—Soil auger, made by welding a carpenter's 1½-inch auger to an iron rod with handle, making the auger six feet in length. The screw point and side cutting edges should be filed off the auger and the points of the worm bent down slightly.

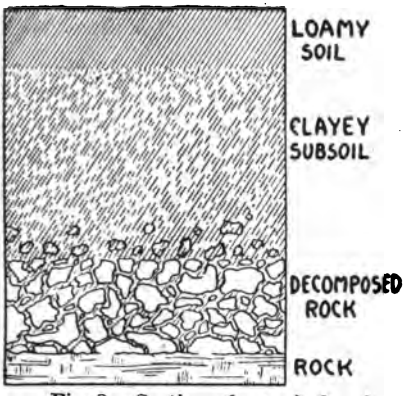

Fig. 2.—Section of a typical residual soil showing gradation from soil through clay, rotten rock to solid rock.

by the destruction of rock masses, the disintegrated and decomposed fragments accumulating on the surface of the hard rock to form the soil mass. Residual soils usually have a surface soil six or eight inches deep, resting on heavier material that grades to a clay at two or three feet in depth. At greater depths rock fragments are found in the clay and these grow more numerous until the mass is largely broken or "rotten rock," and finally the solid rock mass is reached. (See Fig. 2.) The total depth of the soil mass above the rock varies greatly, but usually is less than four feet.

In the humid regions, the transplanted soils, other than those formed by glacial action, are of little extent. The flood plains and bench lands along the rivers and creeks are exceedingly productive, but their total area is small compared with the residual and glacial soils.

In California, as in all sub-humid regions, the residual soils available for agriculture are of limited extent. They are found on hill slopes and on mountain sides and their topographic position makes irrigation exceedingly difficult or impossible, while the shallow soil mass makes dry farming precarious. In the Coast Ranges and on the Sierra foothills are some successfully farmed residual soils, but their total area is relatively small.

By far the larger portion of the agricultural lands in the State are transported soils. For uncounted ages the winter rains have been washing the rock fragments from the mountain sides and carrying the material out to the valleys, spreading the mass out as broad sloping alluvial fans or as relatively flat valley floor. The accumulation of sediments in the valleys is often hundreds or even thousands of feet deep (Fig. 1).

Soils formed in this way may be quite uniform to great depths or may be made up of successive layers of varying texture, sands, silts, gravels or clays. As the soils are laid down a little at a time, year after year, they have been acted upon by the weathering agents, breaking up the particles and making the plant food quite available. Under the climatic conditions that exist, with the hot dry summers and the low rainfall coming in winter, the weathering action of air and water, the beneficial action of bacteria and the formation of humus in the soil, occur to considerable depths. Roots ordinarily penetrate to depths of six to eight feet below the surface. In studying the soil, it is necessary to consider at least a six-foot section instead of the usual three-foot section of the humid regions. The climatic conditions of the region and the mode of formation of the soils, have brought about many

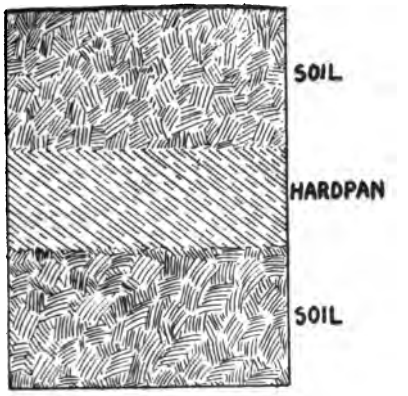

Fig. 3.—A hardpan layer with loose soil material beneath it. Breaking up the hardpan will allow roots and water to enter the substratum of good soil.

features that are not common to the soils of a humid region. Owing to the lack of rain, the soils have never been subject to any degree of leaching and most of the soluble materials have been left in the soil masses.

Hardpan.—Where the soils are old and have been subjected for thousands of years to an annual rainfall that has wetted the mass to a depth of only two or three feet, some of the soluble material has been carried down and deposited, cementing the grains together to form a hardpan. In this way, the iron and lime-cemented hardpans common to the older, thoroughly weathered, red and brown soils, have been formed. In most cases, the material beneath the hardpan is loose soil very similar to that above the hardpan (Fig. 3), and if the pan is broken by dynamite or other means, irrigation waters and plant roots will readily work down into the underlying soil mass. In such cases the hardpan is not a serious factor, as it ordinarily re-cements very slowly. In some cases the hardpan is underlaid by a compact, semi-cemented layer of soil, sand and gravel that is practically impenetrable to water or to plant roots. (See Fig. 4.) With such soils, dynamiting the hardpan is of little or no value, as there is no good soil beneath for the roots to penetrate and no opportunity for drainage or aeration through the substratum.

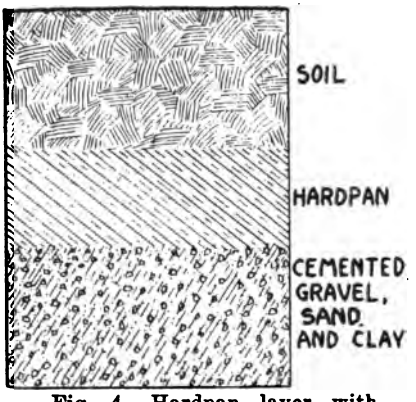

Fig. 4.—Hardpan layer with compact material beneath. Breaking the hardpan will be of little benefit because of the cemented nature of the substratum.

There is another class of hardpan that has been formed at the same time that the soil was formed. This occurs where variations in the soil-forming activities caused a layer of soil to be deposited, then a layer of material that cemented to a hardpan, then another layer of soil, another layer of hardpan, and so on. (Fig. 5.) These hardpan layers are hard to handle, as blasting is not satisfactory unless each of the layers is broken. The hardpan layers do not, however, exist as continuous sheets because in the process of formation of the soil, portions were washed away, the space being filled with other soil material. This, together with the fact that the hardpan is often cracked and sometimes rather soft, gives opportunity for irrigation water and plant roots to penetrate to considerable depths.

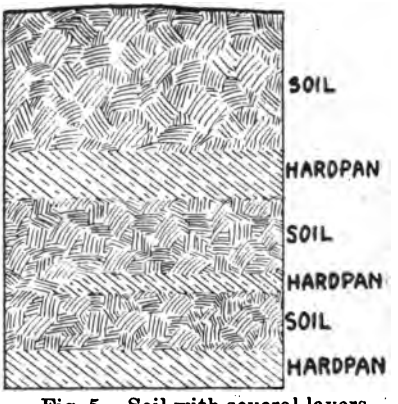

Fig. 5.—Soil with several layers of hardpan with soil between the layers.

Alkali.—Wherever the drainage conditions are poor and there is a larger amount of water passing from the surface by evaporation than passes down through the soil mass, there is the possibility of an accumulation of soluble material or "alkali" on the surface. The term "alkali," as ordinarily used, includes any soluble materials present in sufficient quantity to be injurious to plants. The most common materials are sodium chloride or common salt, sodium sulphate or glaubers salt, and sodium carbonate or washing soda. This "alkali" is not necessarily brought into the soil from

some other location. It is merely a regrouping of the chemicals that existed in the original rock, and the concentration of these compounds in the surface soil because of excessive evaporation.

If the soil has good natural drainage, any excess of water will percolate through the soil and will seep out to the country drainage channels, carrying with it in solution, small quantities of the soluble salts. In such cases, the waters evaporated from the surface cannot exceed the amount that passes down through the soil, and alkali accumulations cannot occur.

If the natural drainage conditions are not good, artificial drainage will be necessary if the land is to be irrigated and farmed. In arid regions, the irrigation of poorly drained lands will produce conditions that will ultimately bring about the accumulation of injurious amounts of alkali. It is necessary to study the drainage conditions carefully, noting the character of the soil with respect to permeability and the penetration of water, the character of the substratum, the slope of the land and the possible outlet for drainage waters. The possibility of drainage waters seeping into the soil from higher lying lands should also be investigated.

Texture and Structure.—The texture and structure of the soils need considerable attention. Because of the low rainfall and absence of leaching, the coarser soils, sands, and sandy loams are much more productive in an arid region than are similar soils in a humid country. If the soil is too loose and open, however, there is a great difficulty in irrigating, owing to excess seepage and in addition the humus is readily "burned out" and lost. On the other extreme, the clays and clay adobes are so compact and impervious that they are very difficult to irrigate, the water penetrating very slowly. Such soils are also difficult to till and to maintain in a proper state of firmness.

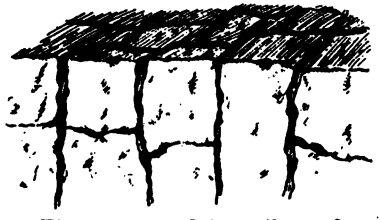

Fig. 6.—An adobe soil, on drying, shrinks markedly and breaks into blocks, with wide cracks between.

The term "adobe" does not indicate a specific kind of soil but refers to the structure. There are clay adobe, loam adobe, and even sandy loam adobe, although the latter is very rare. The name is given to any soil which on drying shrinks markedly and breaks into blocks with wide cracks between. (See Fig. 6.) An adobe structure is undesirable because the soils dry out, not only from the surface but also from the sides of the wide cracks. In irrigating, the water must first fill the cracks and then slowly soak into the hard baked block.

On wetting, the blocks swell up and close the cracks, which reopen again on drying. Considerable injury to plants may occur through the breaking of roots that cross the lines of the cracks and through the drying of many of the feeding roots.

The soils of California are exceedingly productive. They may be compared to the rich bottom lands of the humid regions. The unfavorable conditions that may exist, such as hardpan, alkali, poor drainage, poor structure, etc., can be readily recognized. The presence of alkali can be determined by chemical means or by noting the character of the vegetation and the condition of the surface soil. Drainage conditions, texture and structure, and the presence of hardpan can be determined by examining the soil, boring in it with a soil auger (Fig. 7). The prospective settler should not be content with the examination of the surface soil, but should bore frequently, examining the soil to a depth of at least six feet and carefully noting conditions, bearing in mind that plants that would in a humid region send their roots two or three feet into the soil, will here have a root penetration of six to twelve or more feet.*

* Dr. E. W. Hilgard writes: "While much detail cannot of course be given within its scope, I think the part dealing with the selection of land should be somewhat enlarged, as being of prime importance, and in some

respects most likely to give the newcomer from the humid region trouble.

"First, I think it should be told him somewhat more definitely that the light sandy and silty nature of our soils is not, as would be the case in the East, a sign of poverty, but that these are among our most substantial lands. And as he will naturally be looking for a 'substantial subsoil,' he should be told that the surface soil here is not from three to nine inches deep, but that it counts by feet, usually three or more, and the absence of a subsoil does not mean that the land will be 'leachy,' but is a distinct advantage for root penetration. He should also be told that a gray soil in California is not necessarily poor in humus, and that the surface foot very frequently contains less humus than the second and third foot, where the development of the roots, from the decay of which the humus is usually derived, is most copious.

"The somewhat elaborate discussion of hardpan may lead the newcomer to believe that hardpans are the most prominent features of California soils; whereas the great depth and uniformity of soil masses is certainly the most characteristic feature of the bulk of California lands."

ASSESSOR'S C